GREAT HELL GATE BRIDGE TRIUMPH OF ENGINEERING

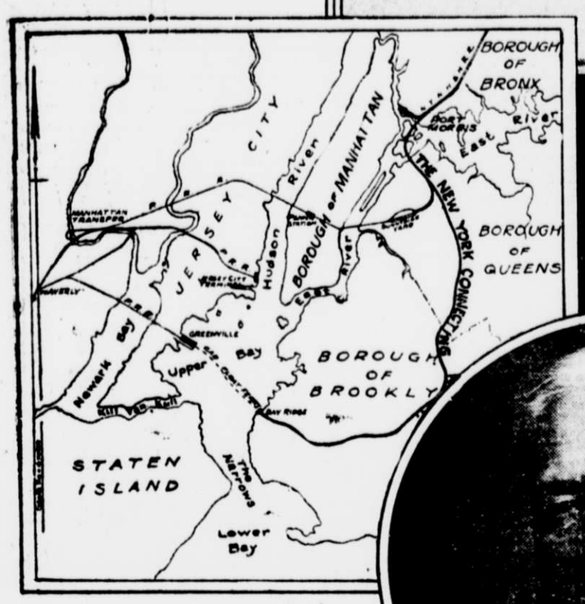
Some of the Problems Met and Conquered in Building Its Huge Steel Arches. Soon to Be Joined.

Other pictures of the new Hell Gate Bridge will be found in the Pictorial Magazine with this issue of THE SUN.

A LITTLE more than a month hence the East River, and particularly that turbulent section known as Hell Gate, will be spanned by the world's most wonderful arch of steel. Then the arms now reaching out from either shore will be joined high above the swirling waters, and a new tie, a massive one a thousand feet straight across, will bind Long Island and The Bronx.

When the Pennsylvania Terminal was finished a few years back the people of this city could not fail to grasp something of that, technical accomplishment, because the beautiful station grew right up out of the rocky bosom of busy Manhattan. But relatively few have followed the Hell Gate bridge in its far more spectacular fabrication; and when everything has been taken into account, this latter work is a vaster and a harder undertaking, for comparatively trifling mis-

The base and anchorage of one of the great chords of the Hell Gate span.



Map showing route of the connecting railway over the new bridge.

Photo by Gessford.

Gustav Lindenthal.

takes in conception and execution would involve grave risks and possibly a harrowing disaster. As will be recalled, eight years ago the ill fated Quebec Bridge over the St. Lawrence collapsed during erection, and ninety men were killed and $4,000,000 worth of material dropped into the river.

Some exact and difficult mathematical calculations have been required in order to make certain of the stresses in the members weighing thousands of tons and now overhanging the East River like titanic brackets, and also to be sure of these cumulative forces as the sections grew to the point of union in midstream. When joined the steel arch will have to be able to support not only its own vast weight of 28,000 tons, but the added load of forty-eight of the heaviest locomotives on the four tracks! Unquestionably the bridge can be regarded as the biggest and the strongest in the world, for there is no other bridge in existence or now proposed that is expected to bear a burden of this colossal character.

Gustav Lindenthal, the engineer, who was also identified with the planning and building of the Pennsylvania Terminal, has been the master mind guiding the so-called Hell Gate Bridge from its inception—the dominant figure at every stage of this great work.

"What do I think most distinctive about the Hell Gate Bridge?" said Mr. Lindenthal meditatively. "Well, that's too hard to answer offhand. The layman and the engineer naturally look at such an undertaking from totally different points of view. The average man considers the work as a spectacle or as a means to an immediate end. At best he grasps the structure as a visible whole. He realizes but little if anything of the many difficulties overcome.

"To me as an engineer, on the other hand, the Hell Gate project is all in the day's work, although it represents a lifetime's experience in railroading and in bridge construction. It stands for the harmonizing of many conflicting problems. Some of these were incident to the varied character of the approaches; some of them peculiar to the great span over the East River, and others have been due to foundations made difficult by reason of the nature of the supporting ground.

"Finally I see in the New York Connecting Railroad, of which the bridge at Hell Gate is but a part, the completion of a great artery of transportation—the last link in the railways running down the whole Atlantic seaboard—making it possible for passengers from Boston and other Eastern cities to go straight through to points south and west of New York without recourse to buses or ferryboats.

"As most every one now knows, the connecting railroad is intended to unite the Pennsylvania and the New York, New Haven and Hartford railways, and to this end a route was chosen which in the light of existing physical conditions would accomplish this in the most practicable manner. The line was to branch off from the New Haven at 142d street, cross the Bronx Kill, travel over Randall's Island, again clear the water at Little Hell Gate, and upon a steadily rising grade mount the last section of the western viaduct approach on Ward's Island in order to reach the necessary height for the run far above the East River. With the Long Island shore gained, then by a somewhat easier gradient and a sweeping detour through a built up section of the Borough of Queens to the Pennsylvania's yard at Sunnyside—thus joining up with the tracks passing thence under the East River and through the rocky backbone of Manhattan to the station at Thirty-second street.

"This connecting link through New York city between the railroads in New England and the railroads south of New York had been conceived over twenty-five years ago, but for its realization credit must be given to that railroad genius the late Alexander J. Cassatt, who was also the creator of the gigantic Pennsylvania Railroad passenger station in New York city and its connecting tunnels under the Hudson and the East rivers. The whole great work, tunnels, bridges, yards, &c., will represent an investment of over $150,000,000."

Mr. Lindenthal then called upon one of the engineers of the erection staff at the bridge to describe some of the details of the various phases of the constructional work.

"No latitude was allowed in the location of the railroad," said the engineer, "it simply had to follow the route chosen for it, and the designer of the great span and the approaches had to take conditions as he found them. A populous section of the Bronx had to be traversed, and of course at a height that could not interfere with street traffic. A bascule left bridge had to be provided for the Bronx Kill, which will be deepened by the Government for navigation; another type of bridge for Little Hell Gate, and steadily rising piers in between that would insure an elevation at the East River sufficient to give a clearance above mean tide of quite 135 feet. Physical conditions were anything but favorable to low cost of construction; and it is safe to say that this connecting line, in all ten miles long, represents economy at a prospective total outlay of $30,000,000. Of course the major part of this sum is involved in the building of the Hell Gate span.

"There were two places in approaching the East River from the north where we encountered difficulties. At the Bronx Kill we found troublesome subsurface conditions that obliged us to go down from ninety to ninety-five feet in order to get a stable foundation for the supporting piers, and the nature of the soil was such that the caisson workers had to labor under pretty high pressure. Again, when we came to the western bank of the East River it was necessary to burrow beneath the surface to depths ranging from fifty-eight to 120 feet to reach the rock and to get a firm footing there.

"Under the bridge tower on Ward's Island we used twenty-one great concrete caissons. Some of them were cylindrical and eighteen feet in diameter, while others were rectangular, with dimensions of 30 by 40 feet. These were much larger than the caissons required for the building of any of New York's skyscrapers and went deeper too.

"In order to sink these supports seven months of work was required, because during the operations a very troublesome fissure was encountered which ran diagonally across the foundation space chosen for the western tower of the Hell Gate span. We had to make absolutely sure of the rigidity of the footing, for the thrust from the enormous load of the arch would have to be borne by the foundation. We could not risk any subsequent settlement. This particular arch, the longest and heaviest of its kind, is designed to sustain four tracks, two for passenger and two for freight trains, and must be equal to the maximum burden such service might impose.

"The upper and lower curved members of the arch are technically known as chords, and the lower one is by far the stronger. Yet, as you look at these members from midstream they seem comparatively light until you catch sight of a moving workman, appearing about the size of an ant, and then one's sense of proportion is aroused. The bottom chord is boxlike in cross section and is biggest where it rises from its slanting foundation of stone at the base of the other tower. At that point it is about 11½ feet deep, up and down, and 7 feet across between its flanking vertical walls of thick steel. In the middle there is a dividing bulkhead or diaphragm, and from time to time men must travel from end to end of each member of the chord for the purpose of painting the inner surfaces and watching for the least sign of corrosion or deterioration. At its highest point, or crown, each of the two lower chord members will have a vertical and a horizontal dimension of nearly 7 feet.

"But figures of this sort don't tell the whole story of the massiveness by any means. Section by section the two lower chord members have been raised into place and joined, and the first unit section of each weighed when pinned to its ponderous hinge a matter of 185 tons! This was independent of the connecting vertical panels and diagonals or 'bents,' as they are termed in the parlance of the bridge builder. Because of the enormous weights involved it has been absolutely out of the question to assemble sections or panels on the ground and thus to raise them to their points of juncture. The unit parts have been put in place one by one, and despite what this means in the way of difficult handling and time required, the Hell Gate span has gone forward speedily. In fact, the work is actually ahead of the schedule, which is something rather unusual in an undertaking of so impressive a character.

"For technical reasons an arch bridge instead of a cantilever bridge was decided upon. A cantilever bridge in some particulars would have offered fewer difficulties, but in other ways it would have had serious drawbacks. A cantilever bridge may be popularly described as a succession of seesaws pivoted upon towers but with neighboring ends joined; this union of the counterbalancing weight of the extended arms serving to help out in the support of the intermediate joined arms when sustaining a live load.

"The Hell Gate arch, on the other hand, depends upon its own dead weight and the firmness of the towers' foundations to anchor it and to help the shifting burden of moving trains. But of course the principal difficulty of such a structure is that encountered during building, when section by section the arch grows and rises as it reaches out from each side of the river while the union, which ultimately means strength, has not been effected. How have we been able to hold increasing hundreds of tons of steel aloft and make it safe for travelling derricks to work out on the very ends of the growing arch and from that apparently perilous point to raise great girders, &c., high into the air for assembling?

"Here is where we have temporarily had recourse to the cantilever principle in assembling the elements of each half section of the span, and to this purpose we have employed economically material which will later on be used for the immediate support of the tracks destined to traverse the piers of the approaches on either side of the East River. These heavy girders have been just the thing required for the temporary backstays, ties and anchorages needed for the support of the span while hanging in midair and gradually growing across Hell Gate and its dangerous waters.

"This temporary counterbalance or cantilever is something like a titanic letter A lying on one leg with the other in the air, from which ties can be carried to each half arch at two points from either bank. The lower leg rests in a deep trench with its foot firmly planted against the rear face of the neighboring tower, and its apex is anchored by a boxlike arrangement of other girders filled with many hundreds of tons of earth.

"With our backstay installation up at the rear of each tower, the first panel of the span was hoisted in place—resting at the bottom on two great slanting pedestals with pivoted connections and secured at the top immediately above the unfinished steelwork by means of girders used as temporary ties to carry the latter's stress rearward to the upper legs of the cantilevers. When, from each shore, the arch had reached waterward for six panels the outer ends had a sag of quite eight inches and it was necessary to correct this deformation. Therefore, from the top of the cantilever we spread two more ties which joined the upper chord at the top of the sixth panel of each half arch at either side of the river.

"The ultimate union will not take place until the weather is favorable. I mean by that we must wait until the glare of the sun is lessened and until the temperature of the air and the temperature of the steel are identical. For before the middle panel is inserted each half of the then incomplete arch will weigh fully 6,500 tons. The middle panel will weigh 300 tons, and the suspended trackway with its connections to the two sides of the lower chord will bring the total dead weight to 19,000 tons of steel alone. When that union at the centre has been made, then we shall be able to remove all of the temporary cantilever structure, and the arch will stand rigidly and fast upon the granite footholds provided on the river fronts of each tower.

"We are using in the work the largest and biggest rivets that have ever been employed within my knowledge upon an undertaking of this sort. The largest of them are an inch and a quarter in diameter and pass through steel plates which, combined, are five inches thick. On the present Queensbridge the heaviest rivets are only an inch and an eighth in diameter. Only the day before that fatal explosion these heads began popping off like pistol shots, and when enough of them had failed then the suspended steel work crashed into the river.

"The Little Hell Gate bridge is also decidedly interesting, and for the overshadowing neighbor over the East River would be commonly considered a structure of importance. This section has a length of 1,134 feet and is made up of four inverted bowstring truss spans. To the casual observer these bowstring trusses are puzzling affairs, and yet they are composed of linked eyebars 16 inches wide and more than two inches thick.

USES BUSINESS METHODS IN SUFFRAGE CAMPAIGN

Photo by Davis & Sanford.

Mrs. Henry White Cannon.

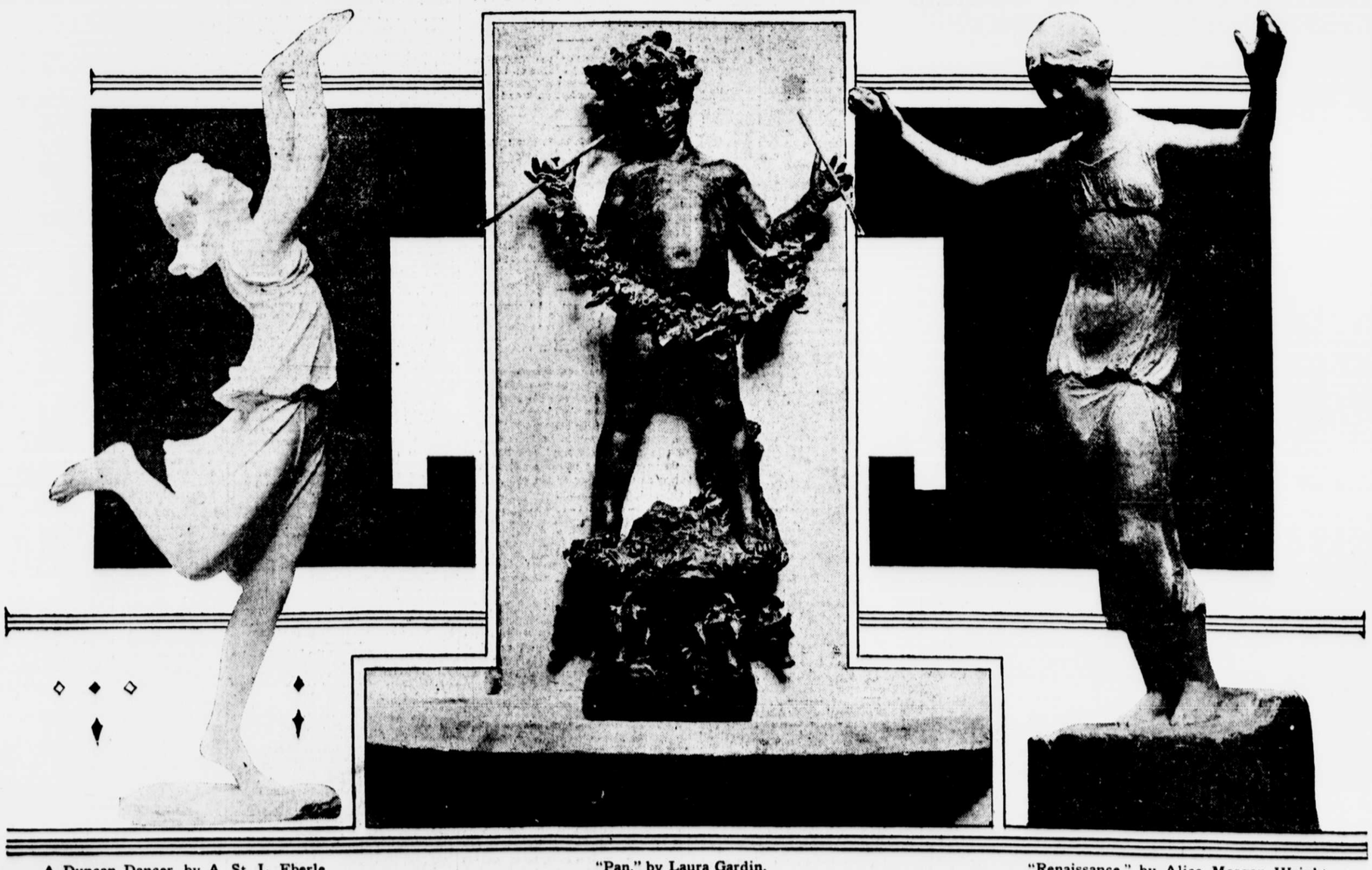
THE "Votes for Women" campaign being conducted in Delaware county, New York, is being cited by the State campaign managers as a model for other county leaders. This is due to the adoption of bankers' methods by Mrs. Jenny Curtis Cannon, the Delaware county leader, whose headquarters are at Delhi. Mrs. Cannon is the wife of Henry W. Cannon, Comptroller of the Currency under President Arthur and afterward president of the Chase National Bank of this city. Mrs. Cannon, in addition to using business methods in getting pledges for the suffrage amendment, is utilizing her ability as a speaker.

Plans for closing the campaign are elaborate and include a mass meeting at Hancock on October 6, when the chief speakers probably will be Mrs. Beatrice Forbes Roberts n Hale, Father John Belford of Brooklyn and Miss Eleanor Garrison, granddaughter of William Lloyd Garrison. Then there will be a whirlwind tour of the county by auto with the idea of reaching the farmers more closely. Every village and hamlet not previously visited will have its meeting and the speakers have been engaged with the view of appealing to the farmers especially.

Under Mrs. Cannon's business methods of campaigning each voter in Delaware county has been listed on a card index and as fast as pledges are secured the names are checked off. Where a village or hamlet does not turn out its full proportion of pledged voters special canvassers are sent there and the women of the village are urged to renew their efforts.

Mrs. Cannon's headquarters in Delhi are probably the most luxurious in the State. Window boxes make the exterior a thing of beauty, as they always are full of blooming plants. Within mahogany furniture, taken from Mrs. Cannon's home, gives unusual charm to the surroundings. A piano and phonograph furnish music for the regular weekly meetings and a tea set is used for the entertainment of visiting guests.

EXHIBITION OF ART WORKS BY WOMEN FOR BENEFIT OF SUFFRAGE



A Duncan Dancer, by A. St. L. Eberle. "Pan," by Laura Gardin. "Renaissance," by Alice Morgan Wright.

Some of the statuary on view at the Macbeth Gallery, the proceeds of the sale of which will go to defray the expenses of the campaign.